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# Falls risk is associated with pain and dysfunction but not radiographic osteoarthritis in older adults: Tasmanian Older Adult Cohort study[1]

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## Summary

*Objective*: To describe the association between knee and hip radiographic osteoarthritis (ROA), a measure of knee pain, stiffness and functional ability and objectively measured physiological falls risk predictors.

*Methods*: Cross-sectional, population-based study of 850 randomly selected men and women aged 50–80 years (mean 62.5, SD 7.4). Falls risk (*Z* score) was determined objectively with the short form Physiological Profile Assessment (PPA). Two observers assessed knee and hip ROA using the Altman atlas. Pain, stiffness and functional ability were assessed using the Western Ontario McMasters Osteoarthritis index (WOMAC).

*Results*: Overall, the study population was at a mild risk of falling. In multivariable analysis, the WOMAC function and pain score were significantly associated with reaction time, balance, proprioception, knee extension strength, and edge contrast sensitivity. Stiffness was associated with knee extension strength and edge contrast sensitivity. Males had a dose response association between the global WOMAC score and falls risk ($r = 0.17$, $P < 0.001$). Those who reported a global WOMAC score of 50 and above had a higher risk of falling compared to those with a score below 50 (*Z* score: 0.53 vs 0.14, $P < 0.001$). Hip joint space narrowing (JSN) was significantly associated with knee extension strength ($r = -0.10$, $P = 0.003$), however, no other significant associations were observed between ROA and falls risk predictors.

*Conclusion*: Self-reported functional ability and pain, and to a lesser extent, stiffness (but not knee and hip ROA), have a modest but independent association with physiological predictors of falls risk.


*Key words*: Falls risk, WOMAC, Knee and hip ROA, Physiological profile assessment.

## Introduction

One of the major problems associated with ageing is the risk of falling, with an estimated 30% of older people living in the community falling one or more times each year[1]. Prevention of falls is important as they are one of the main causes of hospitalisation and injury related deaths in the elderly[2] and as such, leads to considerable morbidity and suffering for older people. Moreover, falls incur substantial social costs due to hospital and nursing home admissions[3,4].

The notion that osteoarthritis (OA), the most prevalent musculoskeletal disease, increases the risk of falling has been repeatedly stated[5–9]. Much of this research, however, has relied on self-reported OA, which may be subject to bias. In subjects with OA, pain is the most common reason for seeking medical intervention[10]. Pain correlates modestly with radiographic change in OA[11–13] despite being the main contributor to disability. Consequently, when considering OA as a risk factor for falls it may be the symptoms, and not the degree of structural change, that lead to an increased propensity to fall.

Pain and stiffness, the major symptoms of OA, occur in 25–50% of patients with radiographic evidence of the disease[14,15]. Leveille *et al.* demonstrated musculoskeletal pain, particularly widespread pain, to be a substantial falls risk factor in elderly disabled women[16]. Balance, a fundamental component of falls risk, has also been associated with higher pain scores in patients with severe knee OA and weak knee strength[17]. Consistent with this, subjects with self-reported OA have worse postural stability and weaker knee extension strength[9,18]. However, there is little data on site-specific arthritis and falls risk measures. What is more, the relationship between physiological falls risk predictors and osteoarthritic symptoms have not been examined.

The aim of this study, therefore, was to describe the association between objectively measured falls risk predictors, knee and hip radiographic osteoarthritis (ROA) and a measure of pain, stiffness and functional ability in a population-based random sample of 50–80 year old men and women.

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## Materials and methods

### SUBJECTS

This study was conducted as part of the Tasmanian Older Adult Cohort study (TASOAC), an ongoing prospective population-based study that began in 2002. Men and women between the ages of 50 and 80 years were randomly selected from the electoral role in Southern Tasmania. Subjects who were institutionalised were excluded from the study. The Southern Tasmanian Health and Medical Human Research Ethics Committee approved the study, and all participants gave written informed consent.

### DESCRIPTIVE VARIABLES

Height was measured to the nearest 0.1 cm (shoes and socks removed) using a stadiometer. Weight was recorded to the nearest 0.1 kg (shoes, socks, and bulky clothing removed) using a single pair of electronic scales (Seca Delta Model 707) that were calibrated using a known weight prior to each testing session. Body mass index (BMI) was also calculated in kg/m$^2$ (for weight/height).

### FALLS RISK ASSESSMENT

The short form Physiological Profile Assessment (PPA) (Prince of Wales Medical Research Institute, Sydney, Australia) was used to assess falls risk. This has been described in detail elsewhere[19]. The PPA is a reliable and valid tool for assessing falls risk in older people. Based on the results of five physiological domains (vision, reaction time, proprioception, strength and balance), the PPA uses a discriminant function to compute a falls risk score (standardised score) for each individual. This measure has a 75% predictive accuracy for falls in older people[20,21]. Falls risk scores below zero indicate a low risk, scores between 0 and 1 a mild risk, scores between 1 and 2 a moderate risk, and scores above 2 indicate a high risk of falling.

### KNEE PAIN, STIFFNESS AND FUNCTIONAL ABILITY

Pain, stiffness and functional ability were assessed by self-administered questionnaire using the Western Ontario McMasters Osteoarthritis index (WOMAC)[22]. Each dimension was assessed separately with a 10-point scale from 0 (none) to 9 (most severe pain, stiffness or functional disability). Each score was then summed to create a total score for each sub-scale (pain: range 0−45, stiffness: range 0−18, and functional ability: 0−153). In addition, all three dimensions were summed to give a global WOMAC score (range 0−216).

### X-RAY

A standing anteroposterior (AP) semi-flexed view of both knees was performed in all subjects. Radiographs were then assessed utilising the Altman atlas[23]. Each of the following was assessed on a scale of 0−3: medial joint space narrowing (JSN), lateral JSN, medial femoral osteophytes, medial tibial osteophytes, lateral femoral osteophytes and lateral tibial osteophytes. Each score was arrived at by consensus with two readers (VS and HC) simultaneously assessing the radiographs with immediate reference to the atlas. Intra-observer repeatability was assessed in 40 subjects with intra-class correlations (ICC) of 0.65−0.85.

Weight bearing AP pelvic radiographs with both feet in 10° internal rotation were obtained and then assessed in the same manner, using a 0−3 scale where 0 = no disease and 3 = most severe disease. Features assessed included axial JSN, superior JSN and osteophytes. Each score was arrived at by two readers (VS and HC) simultaneously assessing the radiographs with immediate reference to the atlas. Intra-observer repeatability was assessed in 40 subjects with ICC of 0.60−0.87.

Rheumatoid arthritis (RA) was ascertained by the following question "Have you ever been diagnosed with rheumatoid arthritis?"

### DATA ANALYSIS

Linear modelling with parametric methods was used for analysis. Univariable methods were utilised initially to examine associations with falls risk measures and WOMAC sub-scales, in addition to ROA. Results were then adjusted for sex, age, BMI, ROA and RA where appropriate. Finally, the subgroup analyses were adjusted for the WOMAC subscales, although pain, stiffness and function were adjusted for ROA only due to co-linearity between the WOMAC subscales. A model was constructed containing the WOMAC global score, knee and hip ROA and their interaction terms (WOMAC × knee ROA and WOMAC × hip ROA). Statistical significance was determined based on the *P* value for the interaction term. All results were adjusted for age and sex. Comparison of means between groups was conducted with analysis of variance and *post hoc* Scheffe analyses. A *P* value less than 0.05 (two-tailed) or a 95% confidence interval not including the null point was considered statistically significant. All statistical analyses were performed on Intercooled Stata 8.2 for windows (StataCorp LP).

## Results

A total of 850 subjects (response rate 57%) (males: 424, females: 426) with a mean age of 63 years were included in this study. Table I presents the characteristics of the study population. Knee JSN (males: 65%, females: 69%) and hip JSN (males: 34%, females: 40%) were common in both sexes. Self-reported RA was present in just over 10% of the population. Overall, the study population was at mild risk of falling, with mean *Z* scores of 0.09 (SD 0.79) for males and 0.27 (SD 0.27) for females.

Tables II and III, and Fig. 1 document the univariable and multivariable associations with falls risk (*Z* score) for WOMAC sub-scales and ROA. In univariable analysis for males (Table II), age and BMI were significantly associated with falls risk. After adjustment for confounders, only the total pain and function scores were significantly associated with falls risk. When the analysis was stratified by age, a significant association was present between falls risk score and WOMAC function score in younger males (50−60 years old). After adjustment for ROA and RA, the association between age and falls risk was the only significant association to remain for males. In contrast, in females (Table III), age, WOMAC global score, pain, stiffness, functional ability, knee ROA and hip JSN were all significantly associated with falls risk in univariable analysis. After adjusting for age, BMI and the presence of RA, the three WOMAC subscales remained independently associated with falls risk and explained 13−17% of the variation in falls risk, whereas knee ROA and hip JSN were not significantly associated with falls risk. Figure 1 illustrates that females who reported

Table I
*Characteristics of the study population*

| | Males ($n = 424$) | Females ($n = 426$) |
|---|---|---|
| Age (years) | 63.0 (7.5) | 62.0 (7.3) |
| Height (cm) | 174 (6.3) | 161 (6.1) |
| Weight (kg) | 84 (13.1) | 72 (14.4) |
| BMI (kg/m$^2$) | 27.8 (3.9) | 28.0 (5.5) |
| WOMAC (global score) | 15.7 (26.9) | 18.1 (32.0) |
| Any knee JSN (%)* | 65 | 69 |
| Any knee osteophytes (%)* | 14 | 14 |
| Total knee ROA score (range 0–29) | 2.6 (3.3) | 2.8 (3.5) |
| Any hip JSN (%)* | 34 | 40 |
| Any hip osteophytes (%)* | 20 | 18 |
| Total hip ROA score (range 0–36) | 1.5 (2.4) | 1.7 (2.8) |
| RA (%)† | 10 | 11 |
| Falls risk ($Z$ score) | 0.09 (0.79) | 0.27 (0.87) |
| Edge contrast sensitivity (dB) | 20.3 (2.2) | 20.7 (2.2) |
| Reaction time (ms) | 229 (38.3) | 243 (46.7) |
| Proprioception (degrees) | 2.8 (1.3) | 2.7 (1.3) |
| Knee extension strength (kg) | 36.6 (9.6) | 23.7 (8.5) |
| Balance: eyes open (mm) | 48.5 (17.6) | 50.1 (18.4) |

BMI: body mass index; ROA: radiographic osteoarthritis; and JSN: joint space narrowing. The results are reported as percentage for binary variables, and the mean (standard deviation) for continuous variables.

*Note*: High scores in the reaction time, proprioception and balance tests, and low scores for the contrast sensitivity and knee extension strength tests indicate impaired performances.

*Defined as grade $\geq 1$.

†Defined as self-reported RA.

a WOMAC score $\geq 50$ were more than three times likely to fall than those below this cut-point ($P < 0.001$), while males had a ''dose response'' association between falls risk and WOMAC score ($P < 0.001$ for trend).

Table IV displays the univariable and multivariable associations between the WOMAC sub-scales, radiographic measures and the five falls risk components. When adjusted for sex, age and BMI, pain, stiffness and functional ability were significantly associated with all five components, with the exception of stiffness and proprioception. The only significant association for ROA was between hip JSN and knee extension strength. The results differed only slightly when the WOMAC sub-scales and ROA were added to the model. In step 2 of the multivariable analysis, the pain and function scores were significantly associated with all the five PPA domains. Stiffness was significantly associated with edge contrast sensitivity and knee extension strength. In addition, the relationship between hip JSN and knee extension strength remained significant ($P = 0.003$). Figure 2 documents the relationships between each of the five falls risk components and the global WOMAC score.

The knee and hip ROA–WOMAC interaction terms were not significant after adjustment for age and sex (knee: $P = 0.09$; hip: $P = 0.72$). A third interaction term containing both knee and hip ROA by WOMAC was also not significant ($P = 0.24$).

When subjects with RA were excluded from the analysis, the results remained largely unchanged. Noted differences from the results presented include, a significant association between the total WOMAC score and function sub-scale, and falls risk for males in multivariable analysis (both $P = 0.04$), with the relationship between pain and stiffness, and falls risk for females becoming non-significant ($P = 0.13$ and $P = 0.37$, respectively). Likewise, in subjects without self-reported RA, pain and stiffness were not associated with balance in univariable or multivariable analysis.

## Discussion

This cross-sectional study documents that it is self-reported functional ability and pain, and to a lesser extent, stiffness but not radiographic OA, that are modestly but significantly associated with falls risk in community living subjects. Females who reported a WOMAC score $\geq 50$ had more than a three-fold increase in falls risk score when compared with women with WOMAC scores below this level. Males also demonstrated a ''dose response'' association between WOMAC score and falls risk. Consistent results were observed for most of the WOMAC and falls risk sub-scales with the exception of proprioception.

Although hip JSN was associated with weak knee extensors, no other significant associations were observed between ROA and falls risk predictors. This appears to contradict previous research, which suggests that self-reported OA is associated with an increased risk of falling. However, it appears likely that self-reported arthritis reflects pain and

Table II
*Relationship between study factors and falls risk: Z score for males**

| | Univariable analysis $\beta$ (95% CI) | Step 1† $\beta$ (95% CI) | Step 2‡ $\beta$ (95% CI) |
|---|---|---|---|
| Age (years) | **0.03 (0.02, 0.04)** | **0.03 (0.02, 0.04)** | **0.03 (0.02, 0.04)** |
| BMI (kg/m$^2$) | **−0.02 (−0.04, −0.003)** | **−0.02 (−0.04, −0.003)** | −0.01 (−0.03, 0.01) |
| WOMAC | 0.002 (−0.0002, 0.005) | **0.004 (0.001, 0.006)** | 0.002 (−0.001, 0.005) |
| *WOMAC sub-scales* | | | |
| Pain | 0.01 (−0.003, 0.02) | **0.02 (0.004, 0.03)** | 0.01 (−0.004, 0.02) |
| Stiffness | 0.01 (−0.02, 0.04) | 0.02 (−0.003, 0.05) | 0.01 (−0.02, 0.04) |
| Function | 0.004 (−0.00004, 0.01) | **0.005 (0.001, 0.008)** | 0.003 (−0.001, 0.007) |
| Knee JSN | 0.02 (−0.01, 0.05) | 0.01 (−0.03, 0.04) | 0.01 (−0.03, 0.05) |
| Knee osteophytes | −0.02 (−0.06, 0.03) | −0.02 (−0.07, 0.02) | −0.03 (−0.08, 0.03) |
| Hip JSN | 0.04 (−0.004, 0.09) | 0.02 (−0.02, 0.07) | 0.02 (−0.03, 0.07) |
| Hip osteophytes | 0.01 (−0.04, 0.06) | 0.01 (−0.04, 0.06) | 0.01 (−0.05, 0.06) |

BMI: body mass index; and JSN: joint space narrowing.

Bold denotes a statistically significant result.

*Linear regression model was used. The results are reported as regression coefficients ($\beta$) (95% confidence intervals).

†Adjusted for age and BMI.

‡Further adjusted for ROA and RA.

Table III
*Relationship between study factors and falls risk: Z score for females**

| | Univariable analysis $\beta$ (95% CI) | Step 1† $\beta$ (95% CI) | Step 2‡ $\beta$ (95% CI) |
|---|---|---|---|
| Age (years) | **0.04 (0.03, 0.05)** | **0.04 (0.03, 0.05)** | **0.04 (0.03, 0.05)** |
| BMI (kg/m$^2$) | −0.002 (−0.02, 0.01) | −0.002 (−0.02, 0.01) | −0.003 (−0.02, 0.01) |
| WOMAC | **0.008 (0.005, 0.01)** | **0.007 (0.005, 0.009)** | **0.006 (0.004, 0.009)** |
| *WOMAC sub-scales* | | | |
| Pain | **0.03 (0.02, 0.04)** | **0.03 (0.02, 0.04)** | **0.03 (0.01, 0.04)** |
| Stiffness | **0.05 (0.03, 0.08)** | **0.04 (0.02, 0.07)** | **0.04 (0.01, 0.07)** |
| Function | **0.010 (0.008, 0.014)** | **0.010 (0.007, 0.013)** | **0.009 (0.006, 0.013)** |
| Knee JSN | **0.05 (0.01, 0.09)** | 0.02 (−0.02, 0.06) | 0.01 (−0.03, 0.06) |
| Knee osteophytes | **0.04 (0.001, 0.08)** | 0.02 (−0.02, 0.06) | 0.01 (−0.04, 0.05) |
| Hip JSN | **0.04 (−0.004, 0.08)** | 0.02 (−0.03, 0.06) | 0.01 (−0.03, 0.06) |
| Hip osteophytes | 0.01 (−0.05, 0.07) | 0.003 (−0.05, 0.06) | 0.0004 (−0.06, 0.06) |

BMI: body mass index; and JSN: joint space narrowing.
Bold denotes a statistically significant result.
*Linear regression model was used. The results are reported as regression coefficients ($\beta$) (95% confidence intervals).
†Adjusted for age and BMI.
‡Further adjusted for ROA and RA.

dysfunction in older subjects, and our results suggest that pain and dysfunction, rather than radiographic change, increase the propensity to fall. This hypothesis agrees with the observation that pain and disability are the main reasons for persons with OA seeking medical attention[10] and is consistent with a study, in which widespread pain was associated with an increased relative risk of falling[16].

It has been suggested that the WOMAC lacks factorial validity due to the overlap of activities on the pain and function sub-scales[24]. In the current study, it appears probable that the function component captured more information than the pain scale alone. Even though in concept, and if measured separately, both pain and function are independently associated with falls risk. As pain is strongly associated with difficulty in performing daily tasks[25], it could be speculated that the relationship between functional ability and falls risk may be mediated by pain. This is supported by a recent paper which suggested that pain was the main contributor to hand dysfunction[26].

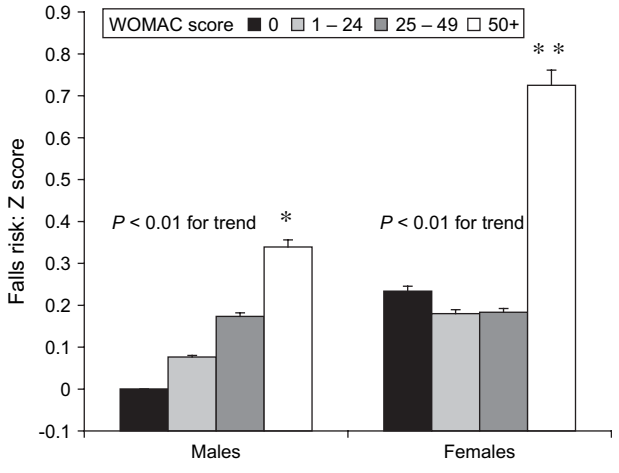


Fig. 1. The associations between falls risk: *Z* score and global WOMAC score for males and females. *P* for trend was adjusted for age and BMI. Results are plotted as mean ± S.E.M. * = $P < 0.05$ in comparison with the 0 (no pain, stiffness and functional ability) group. ** = $P < 0.01$ in comparison with the 0 (no pain, stiffness and functional ability) group. In males there is a dose response while in females there appears to be a threshold of 50.

There was a modest but significant dose response association between the WOMAC score and the falls risk predictors, with the exception of proprioception. Subjects with more knee pain, stiffness and functional deficit had poorer knee extension strength compared to subjects with a lower OA index score. In the final model, the association between the WOMAC sub-scales and knee extension strength was attenuated by adjustment for hip JSN, with knee JSN making little contribution. In a recent report, the alleviation of knee pain resulted in an increased maximum voluntary contraction[27]. A reflex muscle inhibition has been proposed as an intermediate factor on the pathway from pain to muscle weakness[28] and may also explain the association with reaction time. As such, protective balance responses may be impaired by chronic pain and dysfunction, leading to an increased risk of falling.

The observation that pain, stiffness and functional ability are associated with falls risk predictors is important for a number of reasons. In our sample, pain was highly correlated with function and stiffness ($r = 0.81-0.86$) and has previously been shown to be associated with difficulty in performing daily tasks[25]. It would therefore, be expected that pain alleviation would lead to improved functional ability and reduced stiffness. For that reason, encouraging appropriate pain control in the elderly may be one means to lessen the risk of falls. Further studies are needed, however, to determine the validity of pain control as a falls prevention strategy. Secondly, pain is not highly correlated with ROA. Thus, while it is commonly thought that arthritis increases the risk of falling, there are people with arthritic symptoms but no radiographic evidence of the disease, who are likely to be at higher risk of falling. It is therefore, important to treat underlying physiological processes, such as muscle atrophy that accompany symptoms like pain and functional decline.

The current study has a number of potential limitations. The study population was at a mild risk of falling. It is possible that the strength of associations between study factors and falls risk may be different in those at substantially higher risk of falling. Retrospective data on actual falls and fall related injuries were not collected, thus we cannot be certain that identical relationships would exist if such end points were included in the model. However, unlike

Table IV
*Relationship between study factors and individual physiological falls risk components**

| | Univariable analysis $\beta$ (95% CI) | Step 1† $\beta$ (95% CI) | Step 2‡ $\beta$ (95% CI) |
|---|---|---|---|
| A. Edge contrast sensitivity (dB) | | | |
| Pain | **−0.03 (−0.05, −0.01)** | **−0.03 (−0.05, −0.01)** | **−0.02 (−0.05, −0.001)** |
| Stiffness | **−0.07 (−0.11, −0.02)** | **−0.07 (−0.11, −0.02)** | **−0.06 (−0.12, −0.01)** |
| Function | **−0.012 (−0.018, −0.006)** | **−0.012 (−0.018, −0.006)** | **−0.011 (−0.02, −0.005)** |
| Knee JSN | **−0.09 (−0.16, −0.03)** | −0.06 (−0.12, 0.01) | −0.06 (−0.13, 0.02) |
| Knee osteophytes | −0.06 (−0.14, 0.01) | −0.04 (−0.11, 0.04) | −0.01 (−0.10, 0.08) |
| Hip JSN | −0.06 (−0.14, 0.02) | −0.03 (−0.11, 0.05) | 0.01 (−0.08, 0.10) |
| Hip osteophytes | −0.02 (−0.12, 0.08) | −0.02 (−0.11, 0.08) | −0.02 (−0.13, 0.08) |
| B. Reaction time (ms) | | | |
| Pain | **1.20 (0.79, 1.61)** | **1.18 (0.77, 1.59)** | **0.62 (0.18, 1.06)** |
| Stiffness | **2.01 (1.07, 2.95)** | **1.93 (0.99, 2.87)** | 0.84 (−0.20, 1.88) |
| Function | **0.41 (0.29, 0.53)** | **0.39 (0.27, 0.51)** | **0.21 (0.07, 0.35)** |
| Knee JSN | 0.77 (−0.60, 2.14) | 0.06 (−1.31, 1.42) | −0.73 (−2.28, 0.83) |
| Knee osteophytes | 0.61 (−0.98, 2.20) | −0.17 (−1.77, 1.42) | −0.15 (−2.31, 2.01) |
| Hip JSN | **2.52 (0.84, 4.19)** | 1.53 (−0.14, 3.20) | 0.99 (−0.80, 2.78) |
| Hip osteophytes | −0.10 (−2.20, 1.99) | −0.15 (−2.19, 1.90) | −0.15 (−2.31, 2.01) |
| C. Proprioception (degrees) | | | |
| Pain | **0.02 (0.01, 0.03)** | **0.02 (0.01, 0.03)** | **0.03 (0.01, 0.04)** |
| Stiffness | 0.02 (−0.01, 0.05) | 0.02 (−0.004, 0.05) | 0.03 (−0.01, 0.06) |
| Function | **0.006 (0.002, 0.009)** | **0.006 (0.002, 0.010)** | **0.007 (0.003, 0.011)** |
| Knee JSN | −0.02 (−0.06, 0.02) | −0.03 (−0.07, 0.01) | −0.05 (−0.09, 0.001) |
| Knee osteophytes | 0.01 (−0.03, 0.06) | 0.01 (−0.04, 0.05) | −0.001 (−0.06, 0.05) |
| Hip JSN | 0.03 (−0.01, 0.08) | 0.03 (−0.02, 0.08) | 0.02 (−0.03, 0.08) |
| Hip osteophytes | 0.004 (−0.06, 0.06) | 0.003 (−0.06, 0.06) | 0.001 (−0.06, 0.06) |
| D. Knee extension strength (kg) | | | |
| Pain | **−0.28 (−0.38, −0.18)** | **−0.27 (−0.35, −0.19)** | **−0.22 (−0.31, −0.13)** |
| Stiffness | **−0.69 (−0.93, −0.46)** | **−0.69 (−0.87, −0.51)** | **−0.67 (−0.88, −0.47)** |
| Function | **−0.11 (−0.14, −0.08)** | **−0.10 (−0.12, −0.08)** | **−0.09 (−0.11, −0.06)** |
| Knee JSN | **−0.71 (−1.04, −373)** | **−0.45 (−0.72, −0.19)** | −0.28 (−0.58, 0.01) |
| Knee osteophytes | **−0.41 (−0.80, −0.02)** | −0.13 (−0.44, 0.18) | 0.27 (−0.08, 0.62) |
| Hip JSN | **−1.17 (−1.60, −0.74)** | **−0.62 (−0.96, −0.28)** | **−0.54 (−0.90, −0.19)** |
| Hip osteophytes | 0.01 (−0.51, 0.54) | 0.03 (−0.38, 0.43) | 0.26 (−0.15, 0.68) |
| E. Balance (eyes open) (mm) | | | |
| Pain | **0.22 (0.05, 0.39)** | **0.25 (0.08, 0.41)** | **0.20 (0.01, 0.38)** |
| Stiffness | 0.37 (−0.01, 0.75) | **0.42 (0.04, 0.79)** | 0.29 (−0.14, 0.72) |
| Function | **0.12 (0.07, 0.17)** | **0.12 (0.07, 0.17)** | **0.10 (0.05, 0.16)** |
| Knee JSN | 0.54 (−0.01, 1.09) | 0.16 (−0.38, 0.70) | 0.21 (−0.42, 0.83) |
| Knee osteophytes | 0.29 (−0.35, 0.93) | −0.002 (−0.64, 0.63) | −0.14 (−0.88, 0.61) |
| Hip JSN | 0.60 (−0.08, 1.29) | 0.21 (−0.46, 0.88) | −0.19 (−0.91, 0.53) |
| Hip osteophytes | 0.34 (−0.51, 1.20) | 0.30 (−0.52, 1.13) | 0.51 (−0.35, 1.38) |

JSN: joint space narrowing.

Bold denotes a statistically significant result. In multivariable analysis (step 2) sex was significantly associated with A, B and D. Age was significantly associated with A, B, D and E. BMI was significantly associated with D and E.

*Linear regression model was used. The results are reported as regression coefficients ($\beta$) (95% confidence intervals).

†Adjusted for sex, age and BMI.

‡Further adjusted for other factors in table (Pain, stiffness and function were further adjusted for ROA only).

questionnaires, the PPA is not subject to recall bias, and can predict those at the risk of falling with 75% accuracy when the physiological measurements are combined in multivariate discriminate analysis[21]. Furthermore, preventing a fall before it actually occurs is the key outcome in falls research, thus the associations noted in regard to physiological predictors will add an important dimension to our understanding of falls prevention. Secondly, the reproducibility of X-ray reading was good rather than excellent, which may weaken associations. Thirdly, the response rate was reasonable at 57%. This does leave the possibility open for selection bias, which may be a reason for the high rates of ROA and RA in this cohort. However, this is unlikely to bias the associations we report due to the method of analysis. Likewise, due to multiple comparisons, there is a risk of attaining significance by chance. Therefore, all analyses performed are presented in the current paper. Lastly, as this study was cross-sectional, the causality of relationships cannot be ascertained.

In conclusion, self-reported functional ability and pain, and to a lesser extent stiffness (but not knee and hip ROA), have a modest but independent association with physiological predictors of falls risk. Preliminary evidence suggests that the WOMAC may be used as part of a multi-dimensional strategy to identify those at the risk of falling. Furthermore, the alleviation of musculoskeletal symptoms may lessen the risk of falls in older people.

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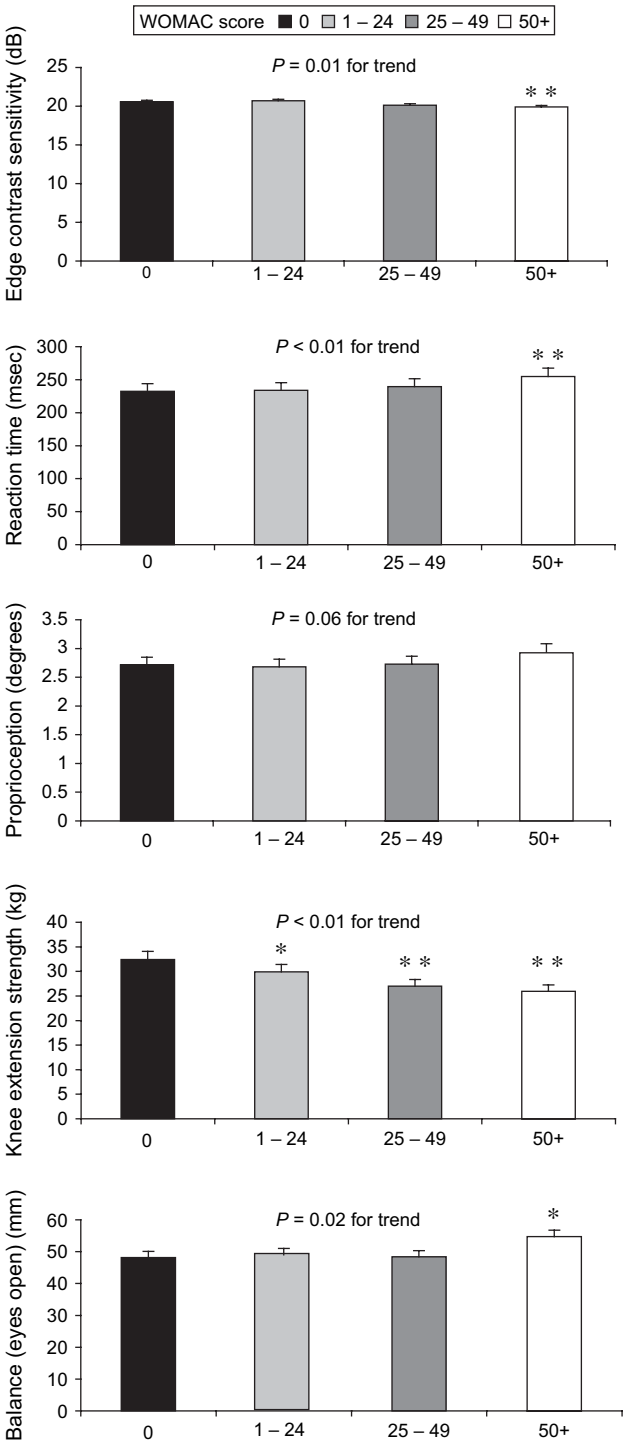


Fig. 2. The associations for global WOMAC score with falls risk measures. *P* for trend was adjusted for age, sex and BMI. Results are plotted as mean ± S.E.M. * = $P < 0.05$ in comparison with the 0 (no pain, stiffness and functional ability) group. ** = $P < 0.01$ in comparison with the 0 (no pain, stiffness and functional ability) group. There is a modest but significant dose response between total pain, stiffness and functional ability and each falls risk measure with the exception of proprioception.

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